TITLE

Solar Powered Piston Pump Assembly

FIELD OF THE INVENTION

This invention relates to a piston pump. The piston pump of the invention is particularly suited to be driven from a solar power source, although it can be used in applications utilising other power sources.

BACKGROUND ART

This specification describes aspects of prior art pumps. However, neither such aspects of prior art pumps nor the description contained herein of such aspects of prior art pumps is to be taken as forming part of the common general knowledge solely by virtue of the inclusion herein of reference to and description of such aspects of prior art pumps.

Solar powered pumps are particularly useful to pump water in remote areas where mains power is not available. The use of solar energy to power pumps imposes some constraints on the pump design. Solar energy sources do not provide power during the night, so the pump should preferably be self-priming. Further, solar energy sources are an instantaneous power source, so they are most efficient at driving a constant load. Therefore it is preferable that the pump be performing work throughout its cycle. Finally, solar energy sources may not always operate at full power, for example if there is cloud cover. The pump should be able to operate at less than maximum power, albeit at a reduced output.

Rotary pumps are commonly used with solar energy sources because they have a constant power requirement and provide a continuous pumping action. Criticisms of rotary pumps used in these applications are that the pumps are not self-priming, and many rotary pumps are not able to pump when running below a

threshold speed. Consequently, such pumps frequently required priming and did not pump on overcast or cloudy days. Since the majority of applications for solar powered pumps is pumping water in bores, the pump was commonly submersed in water, with the resultant failure of the pump if the water leaked into the motor driving the pump.

Piston pumps have been used for bores when driven by a windmill. Most piston pumps have an unbalanced power requirement. For example, when configured in a vertical arrangement, piston pumps require relatively little power on the down stroke of the piston compared to the power required on the up stroke of the piston, when the water is lifted. Further, little water is pumped on the down stroke of most piston pumps. The piston is typically at least partially submersed, so it is inherently self-priming. However, the unbalanced power requirements make them unsuited for use with solar energy sources.

US patent 5,873,411 to Prentiss describes a piston pump in which two pistons are provided in a single casing. The pistons are arranged in an opposing cycle, so that one of the pistons is in an up stroke and the other in a down stroke. This arrangement balances the power requirements of the piston pump and provides far more continuous pumping action. The use of two pistons in a single housing introduces complexity to what is otherwise a relatively simple pump design.

DISCLOSURE OF THE INVENTION

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

In accordance with a first aspect of this invention, there is provided a piston pump for a pumping liquid comprising:

a housing having a liquid inlet and a liquid outlet;

a piston located in said housing, remote from said liquid outlet;

a seal provided between said piston and said housing to divide said housing into a first chamber and a second chamber;

valve means to control passage of liquid from said first chamber through said piston and into said second chamber;

a drive shaft operatively connected to the piston for reciprocal motion therewith, said drive shaft reciprocably movable in first and second strokes thereof;

drive means to reciprocably drive said drive shaft and said piston, said drive means comprising:

a support,

a motor mounted on said support,

a crank driven by said motor,

a crank arm connected to said crank and operatively connected with said drive shaft to transfer drive to said drive shaft,

a longitudinally extending member provided on said support, said longitudinally extending member extending substantially parallel to the direction of reciprocal motion of said drive shaft, and

constraining means provided at the operative connection of said crank arm and said drive shaft, said constraining means is constrained by said longitudinally extending member and movable therealong, and said constraining means and said longitudinally extending member constrain movement of said crank arm such that said crank arm does not impart any

substantial movement to said drive shaft in a direction sideways to the direction of reciprocal motion of said drive shaft, and

the cross-sectional area of the drive shaft is approximately the same as the cross-sectional area between the drive shaft and the housing;

wherein, in use, in said first stroke of the drive shaft, liquid is displaced from the first chamber into the second chamber through said valve means and liquid is discharged from said second chamber via said liquid outlet, and in said second stroke of said drive shaft, said valve means is closed and liquid is displaced from said second chamber and discharged from said second chamber via said liquid outlet, and wherein substantially equal volumes of liquid are displaced in said first stroke and said second stroke of said drive shaft.

Preferably, said longitudinally extending member comprises a channel member.

Preferably, said constraining means comprises a wheel movable within said longitudinally extending member.

Preferably, the drive shaft has a cross-sectional area of between 40% and 60% of that of the housing.

Preferably, the drive shaft has a cross-sectional area of between 45% and 55% of that of the housing.

Preferably, said liquid outlet is provided adjacent a closed end of said housing remote from the piston, the closed end of the housing having an aperture provided therein arranged to receive the drive shaft therethrough, and further seal means provided between the drive shaft and the closed end.

Preferably, the drive shaft is hollow to define a cavity therein.

Preferably, the cavity is filled with a substance that is buoyant compared to the liquid being pumped.

Preferably, the drive shaft is hollow to define a plurality of cavities.

Preferably, the drive shaft is formed from a plurality of lengths of conduit, adjacent conduits being joined at a connector comprising a central portion having an outer surface and two end portions arranged to receive the ends of adjacent conduits thereon, whereby the outer surface of the central portion is contiguous with that of the conduits.

Preferably, a disc is provided adjacent an end of said piston, proximate said valve means, and said seal is provided around said disk.

Preferably, said piston is provided with apertures such that liquid is able to pass from said first chamber via said valve means into said piston and through said apertures into said second chamber.

Preferably, said constraining means is connected to said crank arm.

Preferably, said drive shaft, or a drive shaft extension, extends through a stuffing box means and is connected to said crank arm.

In accordance with another aspect of the present invention there is provided a piston pump for pumping liquid comprising:

a housing having a liquid inlet and a liquid outlet;

a piston located in said housing, remote from said liquid outlet;

a seal provided between said piston and said housing to divide said housing into a first chamber and a second chamber;

valve means to control passage of liquid from said first chamber through said piston and into said second chamber;

a drive shaft operatively connected to the piston for reciprocal motion therewith, said drive shaft reciprocably movable in first and second strokes thereof;

drive means to reciprocably drive said drive shaft and said piston, said drive means comprising:

a support,

a motor mounted on said support,

a crank driven by said motor,

a crank arm connected to said crank and operatively connected with said drive shaft to transfer drive to said drive shaft,

a longitudinally extending member provided on said support, said longitudinally extending member extending substantially parallel to the direction of reciprocal motion of said drive shaft, and

a connector connecting said crank arm and said drive shaft, said connector is constrained by said longitudinally extending member and movable therealong and said connector and said longitudinally extending member constrain movement of said crank arm such that said crank arm does not impart any substantial movement to said drive shaft in a direction sideways to the direction of reciprocal motion of said drive shaft, and

the cross-sectional area of the drive shaft is approximately the same as the cross-sectional area between the drive shaft and the housing;

wherein, in use, in said first stroke of the drive shaft, liquid is displaced from the first chamber into the second chamber through said valve means and liquid is discharged from said second chamber via said liquid outlet, and in said second stroke of said drive shaft, said valve means is closed and liquid is displaced from said second chamber and discharged from said second chamber via said liquid outlet, and wherein substantially equal volumes of liquid are displaced in said first stroke and said second stroke of said drive shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood with reference to the following description of one specific embodiment thereof and the accompanying drawings, in which:

Figures 1A and 1B show a piston pump and associated drive mechanism in accordance with the preferred embodiment of the invention;

Figure 2 is an enlarged view of the piston body of the piston pump shown in Figures 1A and 1B; and

Figure 3 shows a connector used in the piston pump shown in Figures 1A and 1B.

BEST MODE(S) FOR CARRYING OUT THE INVENTION

The embodiment is directed towards a piston pump and associated drive mechanism used as a bore pump for water. Such pumps are typically buried in the ground. Terms such as 'up', 'down' and 'vertical' are used for illustrative purposes in the description of the embodiment. It should be appreciated that the invention could be applied to piston pumps in orientations other than vertical.

Figures 1A and 1B show the piston pump 10 of the embodiment. The piston pump 10 is arranged as a bore pump, with an associated drive mechanism 12.

The piston pump 10 comprises a piston 14 provided in a cylindrical housing 16. The piston 14 comprises a hollow body 18 having a central passageway 20 connecting a first end 22 and a second end 24.

The second end 24 of the body 18 is threaded and receives one end of a hollow threaded connector 26. The outlet of a non-return valve 28 is threaded onto the other end of the connector 26, holding a rigid disc 30 in place between the second end 24 of the body 18 and the non-return valve 28.

The rigid disc 30 has a circumferential recess 32 in which a U-shaped seal 34 is partially received. The rigid disc 30 is slightly smaller than the housing 16 such that the seal 34 bears against the housing 16 to define an upper chamber 36 in the housing 16 above the disc 30 and a lower chamber 38 in the housing 16 below the disc 30.

Apertures 40 are provided circumferentially around the body 18 adjacent the first end 22. The first end 22 is arranged to receive one end 42 of a drive shaft 44, which has apertures 46 provided circumferentially therearound adjacent the one end ~~28~~ 42. The apertures 40 and 46 are aligned so that the upper chamber 36 and the lower chamber 38 are in fluid communication via the non-return valve 28 when the valve 28 is open and the chambers 36 and 38 are separate when the non-return valve 28 is closed. The drive shaft 44 is closed off with a plug 48 above the apertures 46.

A screen 50 is attached to the inlet of the non-return valve 28 to filter particulate matter from the water.

A second non return valve (not shown in the drawings) is provided at the base of the housing 16 beneath the non-return valve 28. On a first stroke, i.e. a down stroke, of the drive shaft 44, the non-return valve 28 opens (and the second non-return valve closes) and the displacement of the drive shaft 44 into the stuffing box 72 produces positive displacement and also pumps water out of the housing 16 via the outlet 68. During the second, i.e. upstroke, of the drive shaft

44, water is lifted up the housing 16 above the disc 30 and so water is discharged from the outlet 68. During this upstroke, the result in negative displacement closes the non-return valve 28 and opens the second non-return valve for entry of water into the first chamber.

In the embodiment the piston pump 10 is submersed in the body of water that water will be pumped from. This body of water may be some distance below ground level. Accordingly, housing extensions 52 (which functionally form part of the housing 16) and drive shaft extensions 54 (which functionally form part of the drive shaft 44) are added to the housing 16 and drive shaft 44 as needed. The piston pump 10, housing extensions 52 and drive shaft extensions 54 are received within a bore casing 56 in the ground 58.

The drive shaft 44 and the drive shaft extensions 54 are formed from hollow PVC plastics material. The drive shaft 44 is joined to a drive shaft extension 54, and adjacent drive shaft extensions 54 are joined together, using a connector 56a. The connector 56a has a central portion 58a and end portions 60 and 62. The end portions 60 and 62 are arranged to be received within an end of the drive shaft 44 or a drive shaft extension 54 for connection thereto by gluing. The central portion 58a has an outer surface 64 which is contiguous with the outer surfaces of the drive shaft 44 and the drive shaft extensions 54 when connected thereto, forming a strong connection without introducing turbulence into the upper chamber 36, which would be the case if the connectors 56 protruded beyond the outer surfaces of the drive shaft 44 and the drive shaft extensions 54.

The housing extensions 52 and drive shaft extensions 54 are preferably formed of a suitable plastics material, such as polyvinylchloride (PVC). Further, the housing 16 is preferably formed of acrilonitrile-butadiene-styrene plastics (ABS) because of its superior wear characteristics compared with PVC.

Connections between plastics are preferably glued. One suitable glue is manufactured by the German company Henkel KGaA under the brand name "Tangit".

An end section 66 is connected to the drive shaft extension 54 furthermost from the piston 14. The end section 66 protrudes above ground and has an outlet 68 provided adjacent one end 70 thereof. The one end 70 has a stuffing box 72 provided therein to close the end 70. One of the drive shaft extensions 54 protrudes through the stuffing box 72 for connection to the drive mechanism 12. A seal (not shown) is provided in the stuffing box 72 which bears against the drive shaft extension 54.

Advantageously, because the stuffing box 72 seals the end 70, the piston pump 10 displaces fluid on the downward stroke of the drive shaft 44. In the embodiment, the housing 16 has a diameter of 50mm and the drive shaft 44 has a diameter of 32mm. Accordingly, the cross-sectional area of the drive shaft 44 is approximately equal to the cross-sectional area between the drive shaft 44 and the housing 16.

This arrangement means that the drive shaft 44 displaces approximately the same volume of water on the downward stroke of the drive shaft 44 and the piston 14 lifts on the upward stroke of the drive shaft 44. Consequently, the piston pump 10 of the embodiment uses similar power in the up and down stroke, making it suitable to be powered by a solar energy source.

In contrast, previous piston pumps used a drive shaft that was small in diameter compared to the housing. As a result, very little water was displaced on the down stroke of the drive shaft, and a large volume of water was lifted on the up stroke. Further, previous piston pumps used solid metal drive shafts that are heavy, further adding to the power required on the up stroke of the drive shaft when used in a vertical arrangement.

An additional advantage is obtained by using a drive shaft 44 that is hollow. The buoyancy of the drive shaft 44 assists the up stroke, assisting to lift the water. The connectors ~~56~~ 56a divide the drive shaft 44 and drive shaft extensions 54 into several chambers. Thus ~~is~~ if a leak develops in the drive shaft, only ~~on~~ one

chamber will be filled, minimising the impact on the operation of the piston pump 10 and simplifying repairs.

The drive shaft 44 is driven in reciprocal motion by the drive mechanism 12, which is described below.

The drive mechanism 12 comprises a support 74 secured into the ground 58. A motor 76 is mounted to the support 74. The motor 76 drives a crank 78 which in turn drives a crank arm 80. The crank arm 80 is connected to the end of the drive shaft extension 54 protruding through the stuffing box 72.

To ensure the crank arm 80 does not impart sideways movement to the drive shaft 44, the crank arm 80 is constrained by a wheel 82 and channel 84 arranged as follows. The wheel 82 is connected to the crank arm 80 and received within the channel 84. The channel 84 is secured to the support 74 parallel to the drive shaft 44. The channel 84 constrains the wheel 82 to movement that is parallel to the drive shaft 44, thereby reducing wear on the stuffing box 72.

It should be appreciated that this invention is not limited to the particular embodiment described above.

For example, the valve may be a non-return valve or nylon ball in a cavity, or any other suitable one-way valve.